INDOOR AIR QUALITY ASSESSMENT

Rockland Memorial Library
20 Belmont Street
Rockland, MA 02370

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of Beverly Brown, Library Director, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Rockland Memorial Library (the library), 20 Belmont Street, Rockland, Massachusetts. On April 4, 2004, a visit was made to this building by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Ms. Brown accompanied Mr. Holmes during the assessment. This request was prompted by reports of musty/mold-like odors in the main hall and stairwell.

The library is a two-story red brick structure built in 1903. An addition was built in 1991-1992. The library consists of the circulation desk, reading areas, periodical section, work rooms, children's library, meeting rooms and offices. Most windows in the building are openable.

Methods

BEHA staff conducted a visual inspection for standing water, water-damaged building materials and microbial growth. Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Photo Ionization Detector (PID). Water content of building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

The library has an employee population of approximately 10 individuals and may be visited by as many as 350 individuals daily. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate air exchange. A heating, ventilating and air conditioning (HVAC) system, which consists of two rooftop air handling units (AHUs) (Pictures 1 and 2), provides ventilation through ducted wall or ceiling vents (Picture 3). Air is returned to the AHUs by wall and/or ceiling-mounted grilles via ductwork. This system was operating intermittently throughout the building on the day of the assessment. Thermostats that control the HVAC system have fan settings of "on" and "automatic". Thermostats set to the "automatic" setting were observed during the assessment (Picture 4). The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

Fan coil units (FCUs) located along the base of walls (Picture 5) provide supplemental heating or cooling as needed. FCUs do not have the capability of introducing fresh air; these units *only* recirculate air. FCUs were deactivated in the majority of areas surveyed during the assessment (Table 1).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the system must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum mechanical ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperature readings ranged from 68^{o} F to 75^{o} F, which were close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 36 to 41 percent, which were below the BEHA recommended comfort range in some areas. The BEHA recommends that indoor air relative humidity be maintained in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As discussed, occupant reports of musty/mold-like odors prompted the assessment. In an effort to determine whether water-damaged/mold-colonized building materials were the source of these odors, BEHA staff conducted a thorough visual inspection for standing water, water-damaged building materials and microbial growth. BEHA staff examined conditions above the ceiling plenum, beneath carpeting, in the base of the elevator shaft, in air handling equipment as well as on the roof and outside perimeter of the building. No evidence of visible water damage, mold growth or associated odors were observed.

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth.

Moisture content was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. The probe was inserted into the surface of walls, carpeting and ceiling tiles. The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings that activate the green light indicate a sufficiently dry level (0 - 0.5%); those that activate the yellow light indicate borderline conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%).

Moisture samples were taken in the main hallway and stairwell, in materials most likely impacted by water damage (e.g., gypsum wallboard (GW), carpeting and ceiling tiles). Materials in a number of non-effected areas were measured for comparison. No elevated moisture measurements were recorded in any of the materials tested (Table 1).

Other Concerns

Although no signs of water damage, microbial growth or elevated moisture content were observed, BEHA staff detected a moderately musty odor during the assessment. The most likely source of odors was traced to a hydraulic leak found in the elevator mechanical room, which is near the main hallway. Ms. Brown reported that the equipment has leaked for some time, as evidenced by the soiling of the concrete floor beneath the leak observed during the assessment. To prevent pooling of hydraulic fluid on the floor, library staff placed an aluminum pan beneath the leak (Picture 6). Hydraulic fluids contain VOCs, which can be irritating to the eyes, nose and throat. Over time the organic components can break down producing pungent mold-like odors.

In addition, movement of the elevator in the shaft is similar to the actions of a piston, where pressurization and depressurization of air occurs. Pressure changes to air in the elevator shaft and adjacent mechanical room can force odors to other areas of the building (Pictures 7 and 8). In an effort to determine whether measurable levels of VOCs were present in the building, BEHA staff conducted air monitoring for TVOCs. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC measurements throughout the building were also ND (Table 1). Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling.

At the time of the assessment, BEHA staff recommended: 1) hydraulic fluid be emptied from the pan periodically to prevent breakdown of organic components; 2) soiled areas on the concrete floor be scrubbed with detergent as an attempt to remove residue and 3) the elevator service company be contacted to assess and repair the leak. In a subsequent conversation, Ms. Brown reported that the elevator service company inspected the mechanical room. According to Ms. Brown, due to the cost of replacement parts, funds are not currently available for repairs. Ms. Brown also indicated that the drain pan is emptied on a regular basis; and odors have been significantly reduced.

Several other conditions that can affect indoor air quality were noted during the assessment. The FCUs are equipped with filters that provide minimum filtration to strain particulates from airflow. Ms. Brown reported that filters are changed once per year. BEHA staff examined FCU filters in the main hallway. The filters were observed to have accumulated dust and debris (Pictures 9 and 10). A number of FCUs also had dirt, dust and debris accumulated within the air handling chambers. These conditions may be attributed to non-continuous equipment operation, which allows airborne particulates to settle within the units. In order to prevent equipment from serving as a source of aerosolized particulates, the air handling sections of FCUs should be cleaned regularly (e.g., during regular filter changes). An increase in filter changes per year should be considered.

In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note, increasing filtration can reduce airflow, a condition known as pressure drop. Reduced efficiency of the FCU is due to increased resistance. Prior to any increase of filtration, a ventilation engineer should be consulted to determine whether FCUs can maintain function with more efficient filters.

Conclusions/Recommendations

In view of the findings at the time of this visit, the following recommendations are made:

1. Continue to empty drain pan in elevator mechanical room to help prevent odor migration into occupied areas until repairs can be made to the elevator hydraulic system. Clean soiled areas on floor with detergent and rinse with soap and water.
2. Operate ventilation systems throughout the building continuously during periods of occupancy, independent of thermostat control, to maximize air exchange. Set thermostats to the fan "on" setting to provide continuous air exchange.
3. Operate FCUs to facilitate airflow.
4. Change filters in all air handling equipment as per the manufacturer's instructions or more frequently if needed. Clean interiors of FCUs during regular filter changes.
5. Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

7. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

References

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SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

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Picture 1

Rooftop AHU (1 of 2)

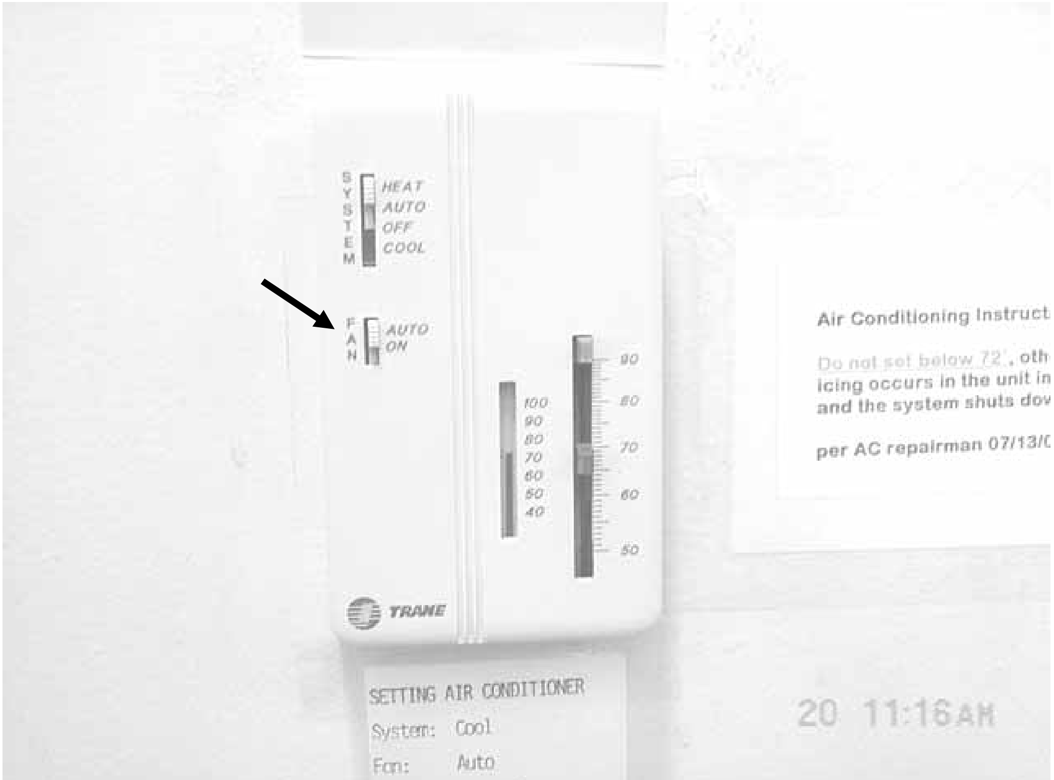
Picture 2

Rooftop AHU (2 of 2)

Picture 3

Ceiling-Mounted Air Diffuser

Picture 4



Thermostat, Note Fan Setting in "Auto" Position

Picture 5

Typical Fan Coil Unit (FCU)

Picture 6

Aluminum Drain Pan for Hydraulic Fluid Leak, Note Soiled Concrete Floor around Pan

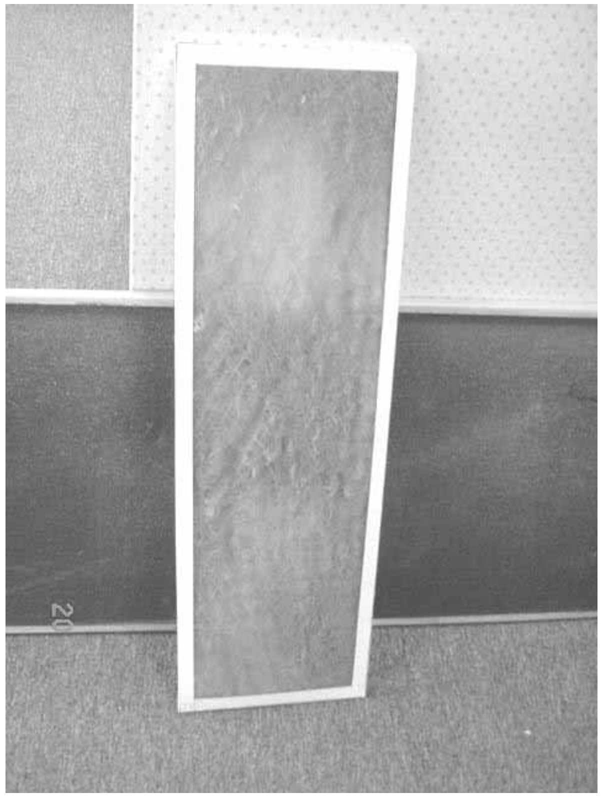
Picture 7

Passive Pressure Relief Vent in Common Wall between the Elevator Shaft and Mechanical Room

Picture 8

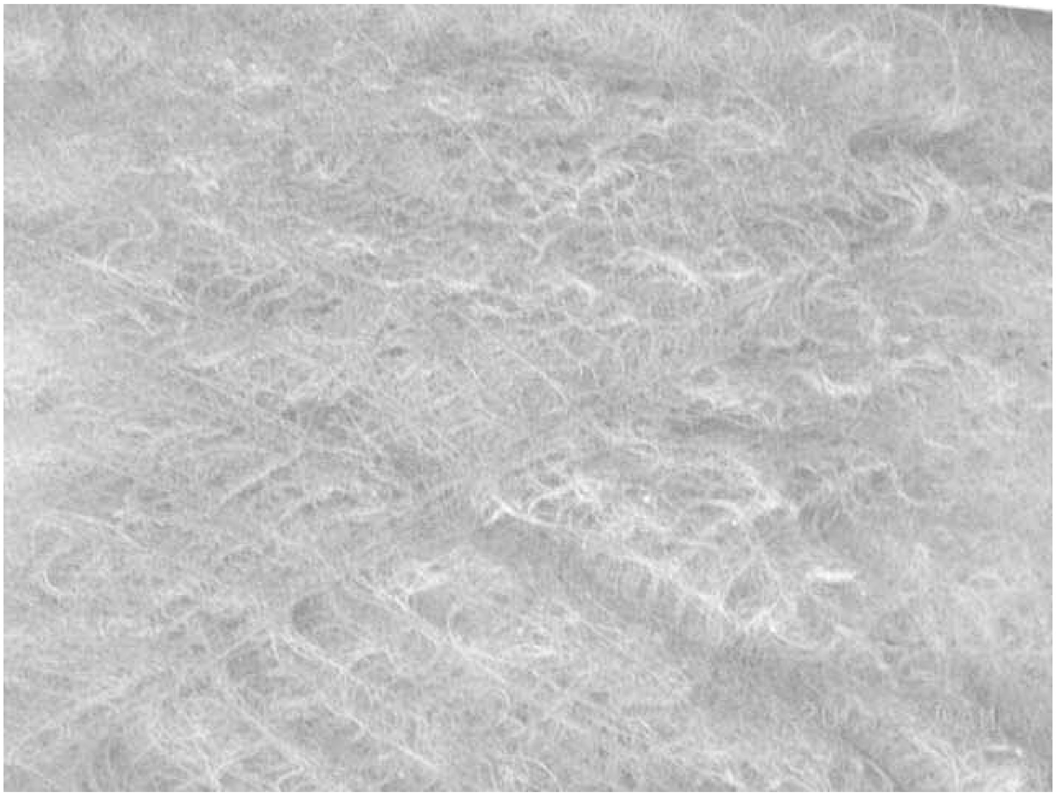
View of Main Hallway from Top of Stairwell Where Odors were Reported/Detected, Arrow Indicates Location of Elevator Mechanical Room Where Hydraulic Leak was Found

Picture 9



FCU Filter in Main Hallway

Picture 10



Close-Up of Filter in Picture 9

Rockland Memorial Library | **Indoor Air Results**
20 Belmont Street, Rockland MA | **April 20, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background (Outdoors)	65	41	389	ND	ND	-	-	-	-	Clear, sunshine, wind: NW 10-15 mph
Main Entrance	68	41	712	ND	ND					Hallway door open; musty odors; low moisture-GW; low moisture-carpets, low moisture-CTs; FCU-off-dusty filter
Elevator Mechanical Room				ND	ND	2		Y Passive Wall	N	Hydraulic fluid leak-accumulation in pan, soiled concrete around pan, passive vent to elevator shaft (pressure relief)
Children's Library	69	40	705	ND	ND	1		Y Ceiling	Y Ceiling	
Reference Computers	72	38	661	ND	ND	5		Y Ceiling	Y Ceiling	
Work Room	73	37	638	ND	ND	2		Y Ceiling	N	
Young Adult	75	37	661	ND	ND	0	Y	N	N	2 FCUs, 1 on

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster
FCU = fan coil unit

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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Table 1

Indoor Air Results
April 20, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Trustees	74	36	685	ND	ND	1	Y	N	N	Hallway door open, 2 FCU's, 1 on
Audio Visual Office	69	41	753	ND	ND	0	Y	Y Off Ceiling	Y Off Ceiling	Hallway door open
Meeting Room	68	40	440	ND	ND	0		Y Off Ceiling	Y off	Thermostat Settings: fan "Auto" and temp "off"
Magazine Rack	70	39	694	ND	ND	2				
Circulation Desk	71	38	679	ND	ND	3		Y Ceiling	Y Ceiling	
Director's Office	72	36	737	ND	ND	1	Y	N	N	Hallway door open; FCU

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